Creating a Collaboratory in Cyberspace: Theoretical Foundation and an Implementation

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Survey

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Abstract:

Internet applications such as the World Wide Web (WWW) have created the possibility of developing global collaborative platforms for supporting interactions between professionals and academics in various disciplines. While Web browsers such as Mosaic and Netscape have revolutionized the way we use The Internet, we envision the need for a theory-based approach to the development of Collaboratories on the Internet. Based on complementarity theory, we provide a conceptual foundation for designing Collaboratories which maximize users' value through the judicious choice of complementary design factors. We emphasize the need for developments in the area of ``open" collaborative systems, and suggest that analyzing the design problem from a complementarity theoretic standpoint can lead to useful insights regarding the value users derive from the system. We also describe the design and an early implementation of an MIS Collaboratory, which uses this theoretical foundation to organize information and to provide a forum for document-centric, multi-media interactions between users. While the prototype focuses on the MIS discipline, we believe that the general principles of our design are applicable to other areas as well.

Key words: Collaboration, rich interactions, information access, Internet, World Wide Web (WWW), complementarity, and open systems.

Introduction

Opportunities and Challenges for Collaboration over the Internet

Recent Internet applications such as the World Wide Web (WWW) and its front-end browsers such as Mosaic and Netscape opened up a vista of opportunities for collaboration among academics and professionals of any discipline on a global basis. The absence of proprietary standards on the Internet make it an ``open'' system, where users from around the globe can communicate and interact with each other without the need to have specific, proprietary end-user applications. Since the introduction of Gopher, the first Internet application which integrated diverse capabilities such as content and location search for information resources, document transfer and remote access, it has become theoretically feasible to create a world-wide platform for rich interactions between a large number of members of any given profession. By virtue of its ability to link information resources anywhere in the world, the Web takes a revolutionary step in the direction of world-wide information dissemination and interactions. In spite of its remarkable potential, we envision a serious problem of Web ``infoglut'' in the near future in the absence of a shared conceptual foundation for the organization of information on the Web. Further, for the WWW to be an electronic forum for productive interaction between researchers and professionals of various disciplines, we see the need to have interactive capabilities integrated with information repositories distributed over the Internet.

Organizing a Collaboratory based on a shared conceptual foundation

In our view, a collaborative system (which we will call a Collaboratory) provides an *open electronic platform* for *individuals* or *groups* with *common interests* to *efficiently exchange*, *disseminate* and *create issues*, *ideas* and *knowledge*. We use the field of MIS as an illustration of our approach to conceptualizing and designing a Collaboratory. However, the ideas presented are general enough to be applied to virtually any discipline. Unlike a proprietary system or application, which provides only a few customization choices to users through limited application programming interfaces, an open system such as the Internet provides a wide range of design choices, which require a careful consideration on part of the developers.

We believe that if properly organized conceptually and technically, the Web can serve as a highly effective foundation for a Collaboratory, which will bring together the diverse worlds of researchers and professionals in various fields. On the other hand, isolated and idiosyncratic developments of Web servers will lead to information overload, inefficiency and chaos. We argue that ``smart agents'', which are sometimes regarded as a panacea for the Infoglut and the information filtering problems, will be less effective when information is organized in a haphazard manner. In addition, without a pragmatic yet sound theoretical basis for assessing the value of interactions among various researchers and professionals, we cannot get a sense of which direction to pursue in terms of future technological developments on the Web. In this paper, we use complementarity theory [2, 3], an old but powerful concept from economics, to develop a model linking a Collaboratory user's net value to the system design features. It provides a rational foundation for understanding the drivers of the value derived by the users of a Collaboratory, and for selecting design characteristics in such a way that maximizes net user value. In the context of Collaboratory design, an application of complementarity theory would suggest that when a Collaboratory can provide a set of related (complementary) features through a single, open user interface, it greatly enhances the benefit to the user while reducing his/her cost of effort and time spent in using the system, thereby maximizing the user's net value. Complementarity theory would also imply that having only a subset of complementary design features in isolation will not bring the desired benefits to the Collaboratory users.

With this perspective, we develop a prototype MIS Collaboratory, which is a Web server with information organized according to our vision of the MIS field. The Collaboratory also incorporates an on-line electronic forum, announcement and search features. The MIS Collaboratory has two main objectives: (i) efficient dissemination of information through organization of information resources, search and resource linking capabilities, and (ii) a global forum for asynchronous and synchronous interactions involving MIS issues, ideas and research articles. We report our experience with the usage of the Collaboratory, as well as some summary statistics of data collected from world-wide participants on the electronic MIS Forum.

The contribution of this paper is twofold. First, it provides a theory-based foundation for designing open, global Collaboratories with the objective of maximizing user value. Given the large number of design alternatives in an open environment, it helps rationalize why certain features of a collaborative system must be provided in tandem to increase user benefits and reduce opportunity cost. Second, it uses the theoretical premise to design and implement what we believe to be the first Web-based interactive electronic forum.

In section 2, we review the relevant prior literature and provide the motivation to develop a foundation for designing computer supported collaborative systems. A complementarity theory based framework for a Collaboratory is presented in section 3. Section 4 focuses on the design of a Collaboratory, while section 5 provides implementation details. Some preliminary experience with the Collaboratory and summary statistics of data collected from Collaboratory users are presented in section 6. We discuss one possible architecture of a global collaborative system involving multiple Collaboratories in section 7. Future research directions and concluding remarks are provided in section 8.

Prior Research and Motivation

Bair [4] points out that most tasks in organizations are accomplished by groups of people rather than by individuals. Chen et al. [5] classify IT systems used to support group activities into two categories: Group Decision Support Systems (GDSS) and Computer-based Systems for Cooperative Work (CSCW). However, in recent years, the term ``groupware" has also found its way into the Group Support Systems (GSS) literature (which includes any system supporting groupwork), and has largely been popularized by commercial products such as Lotus Notes. Huber [6] defines GSS as ``software, hardware and language components and procedures that support a group of people engaged in decision-related meeting". Today's GSS are typically characterized by groupware, which allows users to interact with each other in a variety of ways, ranging from shared database access to video-conferencing, unlike earlier systems which were more limited in geographical scope and functionality. Desanctis et al. [7] define GDSS as ``an interactive computer-based system which facilitates solution of unstructured problems by a set of decision makers working together as a group." Some of the early GDSS were mainly centered around this theme, and involved the use of a single system with multiple terminals to facilitate group interaction. Prior literature [8] suggests that ``many groups fail to adequately define a problem before rushing to judgment." Early research on GDSS focused on this aspect, and therefore concerned itself with problem definition and documentation rather than on issues such as media richness and geographical scope. Over [9] and Kraut et al. [10] indicate that IT innovations did not appear to have facilitated the process of group support.

With the growth of end-user computing and the diffusion of information technology in the business environment, the focus of Group Support Systems shifted toward fusing communication and computing technologies, leading to the emergence of the CSCW field. Johnson et al. [11] define CSCW as ``the use of computer and electronic communication tools as a media for communicating. " Many related fields of research in GSS emerged during this period: Computer-mediated communication, conferencing, and computer-mediated conferencing systems. It was at this point in time that emphasis was placed on

issues such as media richness [12] and communication bandwidth. However, even with the emergence of networking and related tools, the primary form of communication was plain text. One purpose of these CSCW systems was to simulate face-to-face communication, and since text was the only mode of exchange in early environments, computer and telephone systems [13] were combined to simulate a more realistic work environment. A historical perspective of the emergence of this area reveals growth in at least three dimensions from a technological perspective: media richness, geographical scope, and real-time communication capability.

Media Richness

Daft et al. [14] argue that computer based information systems restrict feedback and are not ``rich'' compared to face-to-face meetings. Zmud et al. [12] designed scales to measure the richness construct for different media. A social perspective on media richness involves the ability to convey expressions, pitch, tone, etc. [14]. In our interpretation, however, media richness is a reflection of the bandwidth of communication [15], where the latter refers to the number of different data-types that can be used for interaction. For example, a media rich CSCW system should be able to support not only textual material but also pictures and charts (i.e., graphics), voice and video images.

Geographical scope

Geographical scope refers to the spatial dimension of a GSS or collaborative system, i.e., the ability of a system to cover a certain geographical area. Before the explosion of networking technologies, collaboration was primarily confined to a room or a local area network. Therefore a geographically dispersed CSCW system which required high communication richness could not be based entirely on computer mediated communication, and had to make use of other devices such as telephone or close-circuit TVs. Growth in networking and associated tools led to a more integrated approach, where all functions could be provided through the computing system.

Real-time communication

This characteristic of a GSS defines its ability conduct real-time meetings. Since the early days of GSS, this was predominantly the most important feature as collaboration in a group more often than not required immediate input and feedback. Therefore the ability to simultaneously view and correct a document, for example, would be critically dependent on this characteristic.

Rodden [16] defines group work based on spatial (local or remote) and temporal relationships (asynchronous or synchronous), analogous to geographical scope and real-time ability. He further uses this relationship to separate CSCW systems into four classes, *messaging systems, conferencing systems, meeting systems and co-authoring systems.*

The above review of GSS focus on the ``physical'' abilities and characteristics of such systems, and not the nature of interactions they support. The motivation for this paper stems from the need to support interactions amongst peers in a given discipline in an efficient manner. For example, in the field of MIS, we are interested in interactions amongst IT managers, academics and students. Therefore, while there is a need for a structure to define discussions and interactions with a certain degree of formalism, it is also imperative that no restrictions involving geographical, company or university specific boundaries be placed on such interactions.

Chen et al. [5] observe that research collaboration involves a number of activities ranging from gathering information from different sources, organizing, managing this information to retrieving and sharing for document preparation. While their focus is purely on research collaboration, we tend to take a more general view of collaboration as involving the exchange of ideas and knowledge that may, in addition to helping research, also disseminate information for improving education and practice.

Open collaborative systems on the Web

Many developments in GDSS and CSCW fields took place during a period when the world of computing and communications was characterized by proprietary systems and standards. Hence, most GDSS and CSCW systems were not only platform specific, but also restrictive in their ability to communicate with other systems. While these systems cater well to the needs of specific organizations or workgroups, they appear less suitable for supporting global interactions among people engaged in the collective pursuit of advancing a particular discipline. Even recent groupware applications such as Lotus Notes are based on proprietary standards. For example, while Lotus Notes can work over wide area networks such as the Internet, the end-users must all have Lotus Notes to be able to communicate with each other. These systems are not ``open" in the sense that it is not possible for users with different applications to interact on a global basis. Thus, we perceive the need for creating an open platform where people can engage in information exchange and discussions without being forced to use proprietary applications and data formats. By virtue of being available on a world-wide basis with open client applications like Mosaic and Netscape, the Web appears to be ideally suited as a platform on which such a Collaboratory can be developed. Depending on the file type, Web browsers can seamlessly invoke other applications such as word processing and spreadsheets. For example, using this feature, a user can make available on the Collaboratory a spreadsheet file where s/he has conducted some analysis to support his/her position on the returns from IT investments. Other users can use Netscape to invoke the spreadsheet application, modify the analysis and possibly obtain a different set of results. In other words, a Web based Collaboratory will enable users to reference and access virtually any type of document created by commonly available applications.

Conceptual Foundation for A Collaboratory: A Complementarity Theoretic Perspective

As mentioned above, there is ample motivation to develop a coherent basis for organizing the Web to create an open platform for communication and collaboration within a discipline. Hamalainen et al. [1] suggest that the objective of a collaborative system is ``to fuse computer and electronic communication technology into support systems that improve the pace and quality of discourse among persons collectively engaged in scientific investigations."

In this section, we develop a complementarity theoretic model of drivers of net value to a user of a Collaboratory. This model helps rationalize how certain features taken together will enable Web users (e.g., MIS professionals, researchers and students) to achieve maximum value for their time spent on gathering information and interacting with peers on a Collaboratory.

Factors affecting a Collaboratory user's value

******************* Put Figure 1 about here **************

We have identified three key determinants of the net value derived by a Collaboratory user based on primary goals of usage: *level of information access*, *interaction richness* and *information/interaction cost*. The first two elements determine the gross benefit that accrue to users from spending time on the Collaboratory, while the third element relates to the users' cost of acquiring information and engaging in interactions over the Collaboratory. While we do not imply that our model provides a complete description of user interactions on a Collaboratory, we believe it offers a sound rationale for designing a Collaboratory

based on the concept of maximizing user value.

Information access

One of the major objectives of using a Collaboratory is information gathering, whereby a user can access relevant information dispersed throughout the Internet, without having to travel extensively in Gopherspace or Webspace. Note that this does not imply that there should be only one such central point. That would go against the very spirit of the Internet, and pose an overwhelming administrative load on the site maintaining the Collaboratory. Later, in section 7, we envision a set of such central points distributed throughout the globe, serving as gateways to the field of interest and related information through appropriate organization and context specific search engines. What are the determinants of the level of information access? We focus on three factors, *information organization*, *search engines* and *dynamic linking capability*.

Information organization

As discussed earlier, there is already an information overload on the Internet, as exemplified by the results of queries with popular search engines. While this is definitely a positive indicator of Internet usage and its popularity, it poses the problem of ``Infoglut''. It is therefore important for the information to be organized in some structured form, so as to be easily accessible to the user. While the physical accessibility of data has been well defined in terms of addresses and protocols for various files and formats, there is still an identification problem of how one can obtain access to this information. The traditional way of identification has been keyword based searches (e.g., Wide Area Information Servers (WAIS)), which index words in documents based on efficient algorithms. This still poses the problem of numbers, where large volumes of documents (with or without any relation amongst themselves) have to be searched. To narrow this search further, subject or author based indexing is adopted. While we will shortly discuss some desirable characteristics of search engines, we can make the existing keyword based search work much more efficiently by reorganizing information according to a shared paradigm for the discipline of interest. Therefore, we suggest an *intellectual indexing* of documents and other information resources on a Collaboratory, whereby a set of related documents will be linked to each other. For example, in the world of MIS, an issue such as end-user computing will have many related facets involving technological, social and economic factors. A Collaboratory which organizes information on end-user computing without grouping relevant documents under the above categories with appropriate links between them is likely to be less useful to a user who would like to obtain information on, say, social issues in end-user support. Such a categorization and linking scheme will help a user efficiently locate a set of related documents on a given topic.In the design section, we explain our approach to this intellectual indexing of information for the field of MIS.

Better search engines

Search is central to information access and retrieval. Since we envision a distributed architecture for a set of core MIS Collaboratories across the globe, a document search would involve both location and content. Typical Internet search engines at specific sites maintains WAIS-based indexing schemes. With the proliferation of Web based documents, location now plays a central role in search. Web crawlers or WWW Worms address this problem by traveling in Webspace and searching for documents which meet certain criteria specified by users. However, the efficiency of search can be further enhanced by making them context specific.

Linking documents on Collaboratories

Apart from better information organization and search engines, information on different Collaboratories must be linked together, to enable search engines (like Web crawlers) to travel through the virtual network of Collaboratories. While the Web allows the creation of hypertext links, Collaboratories will have

to support the capability to create such links on a *dynamic basis*, whereby a user who finds a relevant document can immediately link it to a Collaboratory, thereby making it immediately available to other users. In the absence of such a capability, there is the potential danger of creating pockets of hard-to-access information on different Collaboratories.

Interaction richness

Apart from information access, another major purpose of using a Collaboratory is meaningful interactions with other members of the profession, to debate issues and problems of importance and interest, to gain new insights relating to research, practice, and education. We define interaction richness as the extent to which we can overcome the barriers of space, time and media/document formats in interacting with others. This would include:

- Ability to talk, see, write and draw in both synchronous and asynchronous manner

- Access relevant reference information

- Archiving interactions for future review

- Debate issues, problems, ideas, articles, etc. in open public forums on a global basis

The assumption of face-to-face-meeting capabilities of a Collaboratory having a positive impact on user value may seem questionable at a first glance. For example, a considerable section of the literature on GDSS supports the notion that anonymity of interactions can help shy reticent group members participate more freely (e.g., see Valacich et al. [17]) for a related discussion and a review of the relevant literature). In other words, a GDSS which emulates a face-to-face interaction may even lead to undesirable outcomes. While it is possible to customize a Collaboratory for a specific organization for its employees to engage in brainstorming and group activities, we envision a Collaboratory more as a global platform where people with common interests in a field can interact to enhance knowledge and practice within the discipline. Whether a feature like anonymity has a positive or negative impact on the interaction outcomes is an empirical issue, the answer to which really depends on the context of use. However, having features which provide a face-to-face interaction capability, and then selecting only a subset of features depending on the context of interaction will not negatively affect the outcomes. For example, if a research article is being reviewed electronically through the Collaboratory, it may be necessary to mask the identity of the author(s), depending on the guidelines set forth for the review process.

What are the design features which can provide this level of interaction richness? We suggest that interaction richness is affected by *dynamic linking capability*, *synchronous* and *asynchronous communication*, *multimedia support*, and *interaction management*.

Dynamic linking capability

Dynamic linking capability is critical to support interactions based on sound arguments, rationale and empirical or anecdotal evidence. For example, in a discussion of client/server effectiveness on an electronic forum, a user may take a position that client/server allows better integration of diverse computing platforms than a mainframe environment. On an ideal electronic forum (a part of the Collaboratory), the user will be able to create links to documents on the Internet to support his/her stand on the issue or to counter someone else's claim. That is, the user will embed a Universal Resource Locator (URL), Gopher or File Transfer Protocol (FTP) link to some relevant articles, comments or cases (located somewhere on the Internet) within his/her posting about the issue of integration in a client server environment.

Asynchronous and synchronous communication

While the Web does not support real time interactions, and has been primarily used for disseminating information (by storing documents on Web servers), the ability to interact in both asynchronous and synchronous modes should be an integral part of a Collaboratory. While GDSS and CSCW systems achieve this capability within a small geographical region (e.g., on a local area network), such features have to be developed on a global basis. It should be noted that while other Internet applications such as Newsgroups and Internet Relay Chat (IRC) provide the asynchronous and synchronous communication capabilities respectively, they do not support multimedia or hypertext linking capabilities like the Web.

Multimedia support

A Collaboratory should be able to provide full multimedia capabilities to support a wide variety of documents and interactions among users. While the Web does support multimedia documents, the challenge is to bring the same capabilities to a global interactive forum. Of course, the relative importance of multimedia support will vary by the discipline of interest. For example, ability to handle high quality images may be more critical in fields such as Astronomy and Biology than in MIS.

Interaction management

Collaboratories must provide mechanisms to manage interactions in an orderly fashion. For example, if a working paper is put up for discussion, and if users make comments and suggestions, their inputs will be less meaningful in the absence of a way to organize such interactions. If the comments are organized according to their position on the central theme and the methodology of the paper, a new user will find it relatively easy to know what others think about the article. Similarly, the article itself could have been written in a structured form, whereby the authors clearly state their stand on an issue and provide empirical or analytical support for their position. Without such explicit mechanisms for managing discussions and argumentation, it may be impossible to obtain the full benefits that a Collaboratory may offer.

It is also important to be able to link related issues and ideas discussed on a Collaboratory. As the number of discussions grows, this feature will allow a user focusing on one discussion to examine comments and viewpoints that have been expressed on a related topic. It calls for a database environment which can link related discussions, and dynamically reorganize such links based on certain semantic criteria. Note that this linking involves automatic creation of links between topics or issues of discussion based system specified rules. This is different from Collaboratory users embedding links within their comments or postings.

Information and interaction cost

In our model, the cost and the benefit elements are considered as distinct from each other. To justify this modeling approach, consider the fact that different search engines or approaches to organizing information may lead to the same set of documents being retrieved (resulting in the same benefit to the user). However, one engine or information organization approach may be more user friendly and more efficient than the other, whereby the user will be able to perform the search faster and with greater ease. In other words, two different designs can lead to the same benefit (or cost) but different user costs (or benefits).

There is a potentially high cost to the user resulting from information search and interactions. For example, the user may invoke a WAIS-like search engine to look up information on a topic, and be presented with an overload of possibly irrelevant articles, which simply happen to contain keywords specified by the user. Similarly, meaningful interactions involving papers or projects over platforms such as Usenet groups or Internet Relay Chat (IRC) can be tedious for the inability to reference information

dynamically, and the absence of a shared workspace like a Multicast Backbone (MBONE) Whiteboard. This is not necessarily a real dollar cost; rather, it is the opportunity cost associated with the time and effort put in by the user.

With the isolated technologies that exist on and off the Internet, it may be possible to provide a high level of information access and interaction richness (the benefit side); unfortunately, the time and effort (and hence cost) for the user may be prohibitively high. The users' cost increases with poor information organization, less efficient search engines, lack of multimedia support, the inability to interact in asynchronous or synchronous manner, and with poor management of the interaction processes. We argue that by combining features and capabilities in a coordinated fashion within a single system we identify as the Collaboratory, we can simultaneously increase the level of information access and interaction richness while reducing the users' cost. In the subsection below, we address this issue of choosing appropriate combinations of design factors.

Complementarity between design factors

We have already discussed how the design factors are individually beneficial for both the benefit and the cost sides in the value equation. Now we provide examples to show how the above features become much more valuable to the users when they are provided in an integrated manner.

The ability to dynamically link to an information resource to support one's stand on an issue or a proposed model is a key feature of a constructive and scholarly interaction. For example, in a discussion involving the business value of IT, someone taking a position that measurement problems have led to the ``IT productivity paradox" could create a link to one or more relevant articles within his/her comments. While the Web allows hypertext links, it does not come with a platform for asynchronous or synchronous communication. Herein lies the complementarity for the benefit side. The benefit of having the platform and the linking capability together is higher than the sum of values derived from having two systems, one with the linking capability and the other with the forum.

As a second example of benefit side complementarity between pairs of design factors, a Collaboratory that supports multimedia but does not have an interactive feature (e.g., asynchronous or synchronous communication) or vice versa will be less valuable to a user than one which supports both. Consider a traditional Web page, which has multi-media capabilities, but which does not support interactions like newsgroups. On the other hand, newsgroups lack the multi-media capabilities of Web based applications. The benefit of having both features together is very high from the users' standpoint.

In a similar vein, we could take pairwise combinations of various design factors and establish that the value of having them together is higher than the sum of values derived from having them in isolation. Such pairwise comparisons establish the complementarity between all the design related factors.

To understand the cost side complementarity, we note that theoretically it is possible to have all or most of the above features on The Internet in an isolated manner. For example, Web and Gopher sites already have a large volume of relevant information on virtually every topic. The Web also supports multimedia documents. USENET bulletin boards allow asynchronous interactions on a global basis. Internet Relay Chat provides synchronous interaction capabilities. WAIS, Archie, and their derivative search applications allow users to search for documents and their locations. However, from a user's perspective, it is tedious to use one application to locate a document, to open another application to post a comment. In other words, the cost of time and effort will be too high to use separate applications for each aspect of an interaction. On the other hand, having all these capabilities within one system can significantly reduce the users' cost of spending time on a Collaboratory. To be more specific, take the case of information organization and search capabilities. Having better information organization and search capabilities together will reduce the user's opportunity cost much more than either of these alone. Similarly, being

able to dynamically link to, say, FTP sites, but not retrieve diagrams or pictures associated with a document will be much more tedious (and hence costly) than using a system which allows both dynamic links and multi-media documents. As with the benefit side, we can continue this pairwise comparison to argue that when all the capabilities are present simultaneously, the cost to the user is the lowest.

In the above examples of benefit side complementarity, we focused on how various combinations of design choices improved information access and interaction richness (and hence benefited the user). However, there is complementarity between the level of information access and interaction richness as well. A Collaboratory which only disseminates information in an organized way or only supports interactions will be less valuable than one which provides both capabilities. Thus we find complementarity at each level in the value model shown in Figure 1.

It should be noted that while choosing the design factors in a coordinated fashion in the right directions will increase the net benefit to a user, it is not feasible (due to technological and resource constraints) for the designers and developers of a Collaboratory to provide the highest possible levels of these factors. Although we do not provide a mathematical formulation of the Collaboratory designer/developer's choice problem, s/he must consider the tradeoff between the development cost and the users' net value

Complementarity Based Design of an MIS Collaboratory

Organizing information in the MIS domain

Given that there may be thousands of MIS Web sites on a global basis, we envision information search to become a major obstacle to the efficient dissemination of information. While indexing schemes will clearly be helpful, we believe that the way we organize information on an MIS Collaboratory should be a direct reflection of our conceptualization of the field of MIS. We believe that MIS creates new knowledge and value for both academics and professionals by combining technological and managerial viewpoints

The managerial viewpoints come through multiple reference disciplines such as cognitive psychology, economics, organizational behavior, marketing and technical developments (such as GDSS, knowledge representation, etc.). In other words, the technological and managerial viewpoints are complementary, and new knowledge is created at the intersection of IT and the reference disciplines. This visualization is shown in Figure 2.

*********************Put Figure 2 about here*******************

IT refers to computing and communications hardware and software. The reference disciplines enable us to understand how managers invest and use IT, and how IT impacts various cognitive, social and economic aspects of the organization. In other words, for the world of MIS, the area represented by the intersection in the above diagram is more valuable than the sum of the values obtained from pure IT and pure reference disciplines. Through some examples provided below, we suggest that organizing MIS and related information on a Collaboratory according to the above conceptualization will lead to more efficient dissemination of information.

Suppose a user is interested in issues arising in the course of migrating to a client/server environment. What are the technical issues (e.g., database servers, network operating systems, and front-end tools) to be dealt with? What are the organizational implications (e.g., user acceptance, learning, etc.) of moving

to a client/server environment? What are the economic factors involved in such a transition? Are there any studies that document the cost-benefit analysis of such a move? Thus, one single issue like migration to client/server could pose questions that refer to a variety of different fields. The concept of complementarity and its application in the form of organizing the MIS domain provide a solid basis for addressing such questions.

Let us consider another issue that has received wide attention in recent times: Commercialization of the Internet. This aspect of Internet involves a wide variety of topics and sub-topics from advertising to legal issues, from technical challenges to economics analysis of pricing and resource allocation. Academics and professionals interested in this area could possess diverse backgrounds ranging from Economics and Computer Science to Law. If every aspect of the commercialization of the Internet were to be documented, it would be impossible to search through various documents to find one of interest and relevance with a reasonable amount of effort. However if the same issues were to be organized on the basis of our conceptualization, then commercialization of the Internet would fall under the MIS domain with documents annotated with links to commercial sites and academic articles on pricing and resource allocation on the Internet. If there is a reference to some auction or usage-based pricing, it would be easy to categorize such information under the pure Economics discipline. A link to such a document from the MIS domain will shed light on the details of such a pricing scheme. So the value to an user from such an arrangement will be far greater than that from traditional indexing of pages by author names or organizations.

In organizing information on our MIS Collaboratory, we found that almost every aspect of MIS problems could be accommodated under such a conceptual design. Academic and business articles, announcements (e.g., conferences, call for papers, etc.), MIS personnel information, etc. can be organized according to this complementarity paradigm. There is one additional benefit of organizing information in this manner. Since one of the objectives of having MIS Collaboratories is to increase the level of interaction with industry professionals, it is important to ensure that the latter find useful information on a Collaboratory with minimum effort. For example, listing research articles under faculty names can increase the effort required on part of professionals in accessing useful articles. It is unlikely that they will know the names of all MIS academics and their areas of interest. It may be more useful to list articles according to subject areas, and to have links to author resumes from the articles themselves.

Supporting dynamic interactions on the MIS Collaboratory

One of the most important instruments for advancing a relatively young field like MIS is an electronic forum for generating research ideas and stimulating debates involving researchers and practitioners. We saw the Web as a common ground for supporting discussions and providing pointers to existing information resources. The richness of the Web in terms of the data types can be exploited to the fullest by creating forums centered around the Web as opposed to other Internet discussion systems like the Newsgroups. Based on the theory of technology convergence and complementarity, we conceptualized an ideal public CSCW system on the Internet, which will allow person-to-person and group-to-group communication in a multi-media format. The relevant tasks involved in such a communication would include mailing, posting, and viewing rich documents, as shown in Figure 3.

The Internet supports many applications (e.g., Usenet, email, IRC, Multi-User Dungeons (MUD), conferencing) for interaction among users. However, each of these tools has existed in an isolated manner, and typically users have had to access them separately. But for productive interactions, it would be ideal to have an integrated application which provides users all the above capabilities in a seamless manner.

*********************Put Figure 3 about here*******************

Implementation of an MIS Collaboratory

In December 1994, we created an MIS Collaboratory by organizing information according to our conceptualization of the MIS field. Further, in conformance with the complementarity theoretic foundation described earlier, we added an on-line forum for supporting interactions between MIS academics and professionals. While our prototype only has a subset of the features outlined in the conceptual model, to the best of our knowledge, this is the first development allowing global dynamic interactions on the Web. An important feature of the forum is not only its ability to display issues and comments (a traditional Web function as a presenter of information), but its unique capability to allow users to post comments on these issues and discussions. One can also post a new issue for discussion by others.

The key feature of the WWW and its browsers that has made it so popular is the ability to combine multiple tasks. A browser like Mosaic or Netscape can be made to handle news and email, or be used to invoke other applications seamlessly. To illustrate this point in the context of collaboration, consider a setting where a particular document is to be annotated. Suppose an MIS professional visiting our site is interested in making comments on a particular research article, and also wishes to follow up on others' observations. In a traditional Web environment, this single action involves at least two parties, namely the user and the Web administrator. For such a user interested in annotating a document, the typical tasks would include the following:

1. Reading the document to be annotated

2. Writing comments about the document

3. Mailing back comments

For a systems administrator, the tasks involved in putting up the document would include:

1. Saving his/her mail as a file.

2. Converting it to a document in the desired form

3. Attaching it to his/her annotation system

All of the above tasks can be done with the available tools on the Internet. The user could have read the article using a newsreader/presenter, composed his/her comment/reply using an editor, and then mailed back the article. Furthermore, if s/he were interested in receiving comments on his/her annotation, the Web administrator would have had to post the document back on the Web server. However to the user, these separate tasks constitute one related group of actions. Indeed, on our forum (which uses an annotation system), the above scenario is just one seamless process. The user looks at a Web page, reads the article, clicks on a hypertext link that leads him/her to a form; then s/he fills out the comments and clicks on a button, which automatically executes a Common Gateway Interface (CGI) script to post the article in the relevant form on the web page immediately. In this manner, we achieved the interactive nature of newsgroups, but with the multi-media and linking capabilities of the WWW. In other words, our forum simulates the features of Usenet on the WWW, while still allowing users to embed a variety of different URLs (e.g., Hyper Text Transfer Protocol (HTTP), Gopher, FTP, etc.) links in their comments. These features are, of course, in addition to incorporating inline images, audio or even video clips. Some snapshots of the Forum are provided in Figures 4 and 5.

*********************Put Figure 4 about here*******************

*********************Put Figure 5 about here*******************

In our implementation, the MIS Collaboratory server handles user requests, and provides a ``back-end" process for information organization and interaction. As with any Web architecture, the two main communication points are at the server and client ends. A HTTP daemon (httpd) at the server side listens to requests, and a browser like Mosaic or Netscape at the client end initiates communication and displays information. We have three key processes at the server end providing the necessary functionality: CGI processes, search engines, and organized information repositories.

CGI processes

CGI mechanisms allow HTTP requests to execute processes on a remote server through the use of a normal browser and form inputs. These are processes which manage both information dissemination and interaction. The CGI processes have two core duties: document display and request handling. Consider an MIS user who visits the Collaboratory for the first time. The document displayer (a core part of the httpd structure) responds to the browser's request and sends back the main document with embedded links to various other relevant documents and forums. If the user chooses a link to any kind of interaction, a form would be displayed with a button to activate a back-end CGI script. For example, if the user wishes to add a conference announcement, s/he enters the requisite input and submits the document. The request handler deals with this submission request and evaluates it to determine the appropriate repository to place the document. Once the document is placed in the appropriate repository it sends a message to the document displayer unit to update the index document on conference announcements. Thus, both the information positioning and dynamic indexing are handled by this unit.

Search engines

This unit is responsible for searching repositories for relevant information. While we have used a simple keyword based search in our prototype, other search mechanisms like WAIS and Archie with further additions could be used depending upon the repository type and document formats. While our search engine only searches locally, in future refinements, the search engine must be enhanced to search other Collaboratory sites on the Internet as well. Its capability should extend beyond simple textual document search to include searches based on URLs, document types, etc.

We propose that existing search engines can be enhanced with addition of MIME capabilities to include document types so that in addition to a specific key word search, additional qualifications such as document type, location, etc. can be included as meta-fields. Thus, any request for search will be handled by the CGI process, which will then invoke the search engine by passing relevant input parameters. While the user enters input in a normal fashion, a CGI script parses it to provide a suitable string to the search engine, and further redisplays results in a formatted fashion.

Organized information repositories

This is the unit that deals with actual storage of documents (text, audio, video, references to links, etc.). All core information, information added by users and logs of interactions are stored here. Though we have used a simple, flat file system with Unix directory structures to store documents, it is possible to use commercial database servers as well. Such a database would provide better indexing capabilities and also allow construction of optimal query scripts for the CGI processing unit. Dynamic modifications are needed in this repository not only to add new information but also to reorganize from time to time the

``intellectual index" and referencing information.

Experience with the MIS Collaboratory

There has been a significantly positive response to our MIS Collaboratory from academics and professionals from all over the world. Responses range from private email to postings on the system. The users of the Collaboratory have been unanimous regarding the need to bring together not only features of the Internet tools but also relevant information and documents. A noteworthy observation was the global nature of interactions on the Collaboratory. For example, more than 25% of the discussions were initiated by users from countries other than the United States, apart from the responses to issues raised here.

As more users joined the forum, there were many requests for additional features. One such important feature was to ``preview" postings. The need for this capability can be better understood by analyzing features of the browsers and Hyper Text Markup Language (HTML) itself. Since the system allows embedded links, inline images and other URLs, the posting itself has to contain tags for such links. Since HTML is a markup language with tags, it is easy to make mistakes; therefore a mechanism for testing the links and previewing the formatted document is needed to ensure that the administrator will not have to correct syntax errors. This was done by filtering the posting to a temporary buffer before actually writing it to the server.

An alternative to the above approach would have been to allow users to edit their comments directly. This would require maintaining a database, so that only the original user could alter his/her posts. At this point, we deemed this to be unnecessary, as it would add to the complexity of the system and might hinder a first time user from experimenting with the system. However, if we had to customize the Collaboratory for a specific organization, a database environment would be essential. If an organization prefers to conduct its internal meetings and discussions over a Collaboratory, then separate databases would be maintained to handle such discussions with privacy protection and restricted access. The extensions such a system can take are remarkable. For example, we created an announcement system for group interactions of an MBA level class. This allowed students not only to read announcements from the professor, but also enabled them to share information (such as recruitment schedules) with other students by automatically posting to the announcements page.

From our experience, we found that inline images and embedded links were popular only with Web-savvy users, who were already familiar with HTML tags. The primary reason could be the absence of integrated tools like a browser and an editor which supports a What-You-See-Is-What-You-Get (WYSIWYG) environment. With browsers gaining popularity, it should be possible to create a true word-processing type of environment that would eliminate the need to know the markup language on part of the end users. Another significant issue in our implementation is the organization of discussion or rather the need thereof. As the number of issues being discussed grew over time, the need to organize the discussions based on semantic criteria became more apparent. At present, the discussions are arranged simply by their subject along the lines of Internet newsgroups.

To better understand the needs of the Forum users, we conducted a Web based survey where the users were requested to answer questions on their general Internet usage and opinions on the MIS Forum. We present some preliminary summary statistics of user profiles and opinions, without analyzing causal relationships between the Collaboratory design factors and user value. A sequel paper will report a detailed analysis of such relationships. A profile of the 126 users who responded to our survey shows a mix of academics (4.8%), students (32.8%) and professionals (58.4%). 36.8% of the respondents have been using the Internet for 0-1 year, 28.0% for 1-2 years, 14.4% for 2-3 years, 11.2% for 3-4 years, while 9.6% said that they have been using the Internet for more than 5 years. It was also evident that more people are using the Internet for work-related activities. For example, 37.6% said that they used it

``often", while 33.6% indicated that they used the Internet ``very often" for work. In general, the profile of the respondents who used our forum was representative of the sample we wished to test, i.e., a mix of academics, students and professionals, who are not necessarily Internet experts, but who have begun to use the Internet for work related activities. Since our focus is on interactions for the purpose of advancing knowledge and practice in a discipline, casual surfers on the net and those who use it purely for entertainment purposes are not of particular interest to us.

While 40.8% of the respondents felt that our Forum was ``somewhat" of an effective medium to discuss MIS issues, 35% were of the opinion that the Forum was ``quite a bit" or ``very much" an effective medium for collaboration. However, when we asked the respondents to compare our Forum with Usenet newsgroups as a potentially constructive platform for interactions regarding MIS issues, 56.8% rated our Forum as ``quite a bit" or ``very much" better. It is interesting to examine what existing and planned features of the Forum the respondents considered useful. 63.2% and 65.6% of the respondents indicated that the *ability to post issues and comments automatically from any browser* and the *ability to link to documents* respectively were ``quite a bit" to ``very important" features of our Forum. These features enable interactive and document-centric discussions on our Forum. The respondents were not particularly enthusiastic about the ability to embed voice and images in their comments (e.g., 30.4% thought it was only ``somewhat important" to embed images, while 48.0% indicated it was ``not very much" to ``somewhat important" to annotate with voice). We may infer that the importance of multimedia capabilities such as voice and images are influenced by other factors such as available bandwidth, domain of discussion, and the nature of collaboration. For example, one user commented ``too much graphics, my modem cannot handle", thereby indicating a bandwidth constraint. It may also be reasonable to assume that a Collaboratory for a discipline like Biology might see more use of pictures than the field of MIS.

For future enhancements to the Forum, it was clear that a search capability similar to that offered by a relational database was very much needed. 65.6% of the respondents felt that this was an important feature and would increase the value of our Forum. Also, 60.8% felt that there was a need for discussion management, while 60% felt the ability to vote on issues was ``somewhat" to ``quite a bit" important. These are clearly some directions to be pursued in terms of enhancing the Collaboratory. Only 8% saw the need to integrate synchronous conferencing tools like MBONE, Cu-SeeMe with the Forum.

Collaboration: A holistic view

Having considered the design and preliminary implementation of a single Collaboratory, let us now consider a more holistic view of the MIS world using the Web as a collaborative tool. We envision that there will be centers of collaboration which will act as gateways to the linked repositories of MIS related information. This is shown in Figure 6. The key idea is to maintain the distributed nature of the Web, while avoiding excessive duplication of repositories. Since this is a collaborative environment, there is bound to be some amount of duplication of material by servers that wish to maintain a local copy of a certain repository or even a just a single document. Also, if there were to be only one central Collaboratory, there would be an undue load on the server, to be of use to MIS academics and professionals all over the world.

*********************Put Figure 6 about here******************

While it may be difficult to determine an optimal repository distribution strategy, the entire MIS Collaborative environment could be made up of five to seven core Collaboratories distributed across the continents. Further, depending upon usage load factors, there could be ``mirror sites" to replicate the same repositories and the ability to execute similar search agents. While it is a topographical problem to ascertain the geographical locations of these servers, the users are not affected due to the transparent

nature of access to these Collaboratories.

Future Research and Conclusion

As discussed in the motivation section, creating a collaborative environment on the Web adds an ``openness'' to the system, i.e., a system can be designed with flexibility and integration as key features without being restricted by proprietary standards and protocols. While our paper focused primarily on creating a platform for global interactions, we did not concentrate on customizing the Collaboratory for specific organizational requirements or business needs. However the open nature allows for such integration; in fact, a collaborative system on the Web can be developed to handle the integration of workflow with messaging systems and databases. One fruitful avenue for future research involves the use of ``normative scripting'' in Web based collaboration to demonstrate workflow automation both within an organization and on a global basis.

``Normative'' implies conformance to a standard or a norm. Normative scripting refers to scripting workflow and processes in an organization. A script in the context of the Web refers to shell programs or CGI processes, which can be triggered by different actions. By scripting or documenting these actions on the basis of certain rules, an entire process could be automated. As mentioned before, actions on the Web are primarily dependent on two dimensions, i.e, a document and its location. A normative script adds a third dimension to this action, by defining when, how and why a certain document is created and where it is located. For example, consider a Web based system for a marketing group that is collaborating on a marketing plan for a product. This plan may have two facets, one involving a comparison of similar products in the market, and the other an internal decision making process which approves or rejects the plan. A normative script will send out ``smart agents'' like Web crawlers to look for references in the plan to existing products and retrieve the information for the marketing group.

If a business rule of the firm requires that at least two-thirds of the group must agree on a certain plan, then a CGI process can be created to verify the group members' stands, and automatically message the document to a senior manager if there is at least a two-thirds approval. We note that while commercial groupware can handle messaging and workflow automation, they also require adherence to proprietary standards. By normative scripting of processes on a Web based Collaboratory, the same functionality can be achieved on a world-wide basis. Such scripts can be particularly useful for the on-line review of electronically submitted research articles, where they can dramatically reduce the turnaround time for author feedback.

Being a global and open environment, the Web holds the promise of providing a collaborative platform for rich interactions between members of a profession or field. Given the distributed nature of this platform, it is imperative that information on a Collaboratory be organized according to a shared understanding of the field of interest. Along similar lines, a Collaboratory must also support well-managed interactions for the exchange and creation of new ideas and concepts. We suggested that the features of a collaborative system should be chosen to maximize user benefits and to minimize their opportunity cost of using the system. Using complementarity theory, we rationalized how the coordinated choice of certain design features would accomplish this objective. With this complementarity theoretic perspective, we argued that an isolationist view of design focusing only on one aspect such as media richness or geographical scope is unlikely to be of much value for collaboration. Our survey data indicate that users of our prototype MIS Collaboratory worldwide have found it to be a useful means for productive interactions. We plan to enhance the prototype with complementary features which were considered as important by the respondents, and also along the lines of normative scripting for workflow automation.

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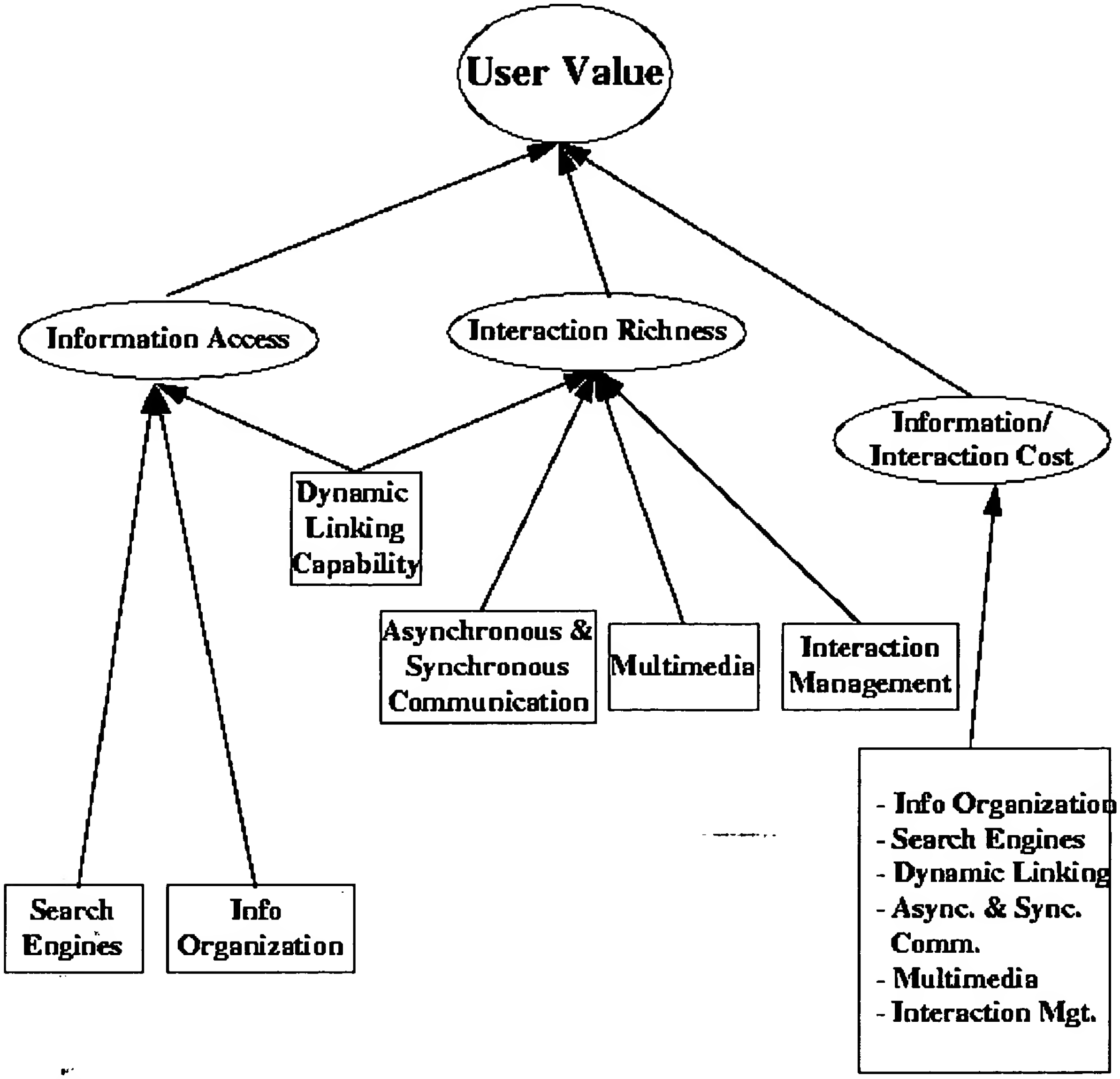

Figure 1: Complementary drivers of Collaboratory users' value

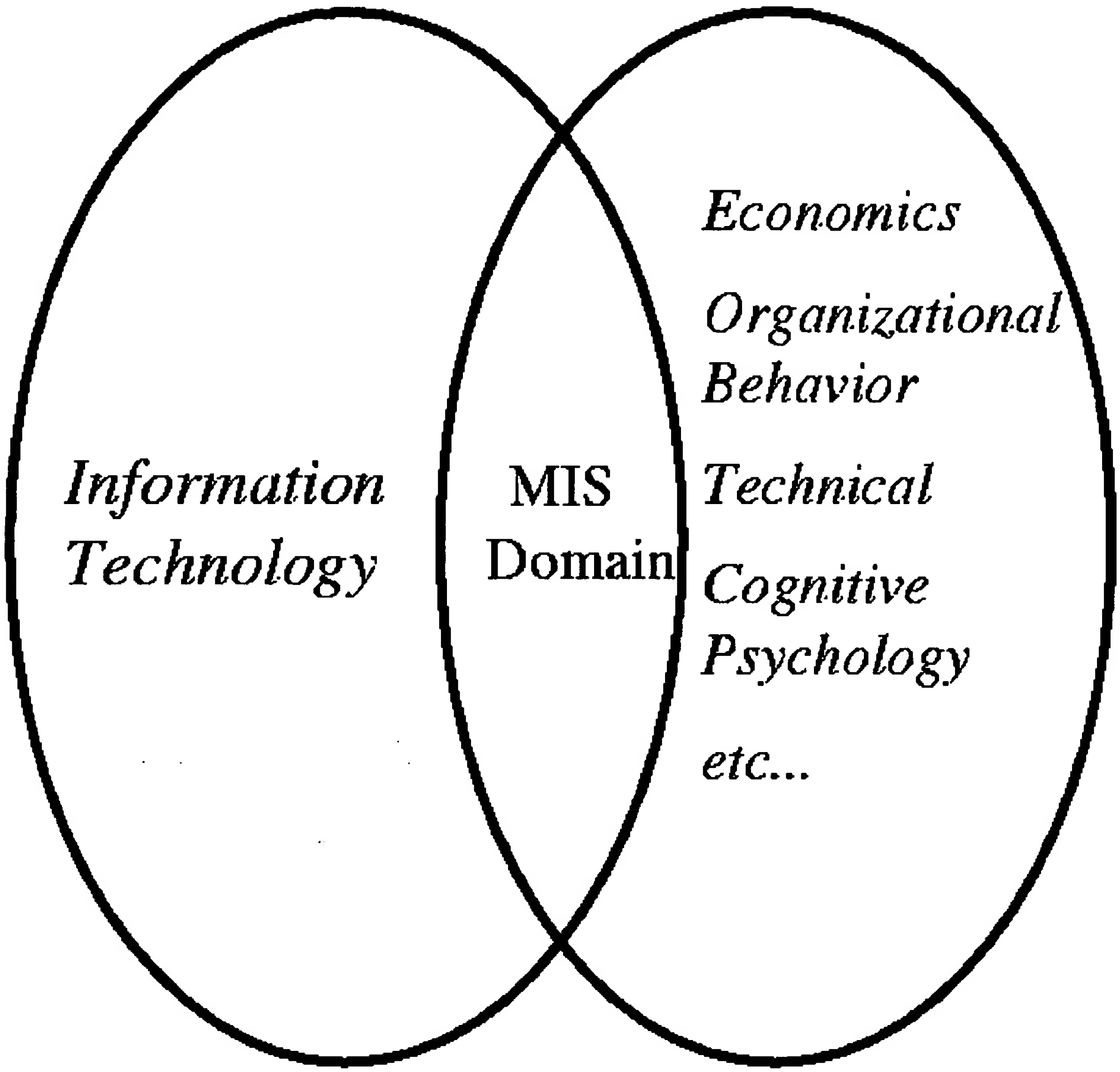

Figure 2: The Domain of MIS

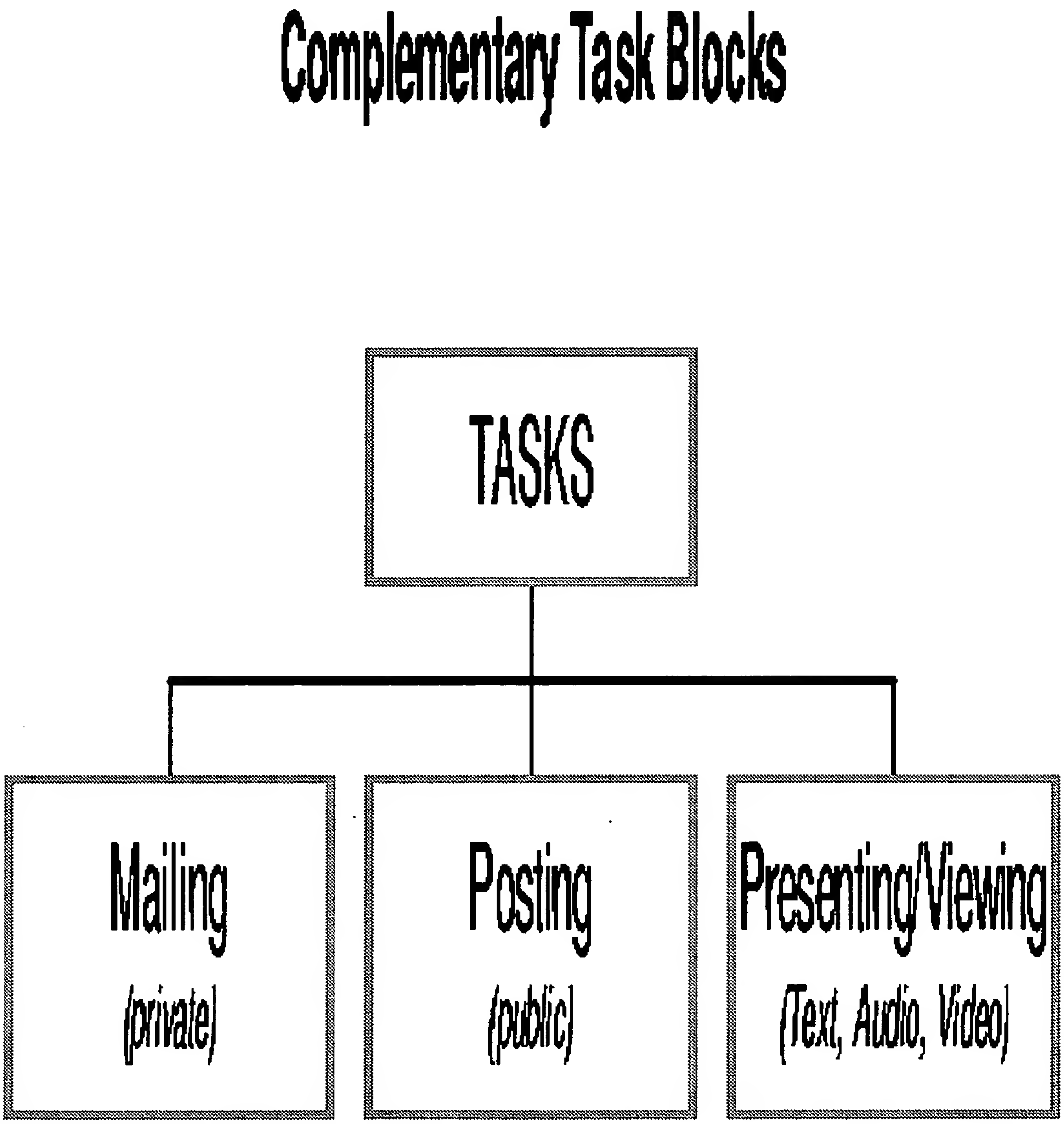

Figure 3: Complementary Task Blocks

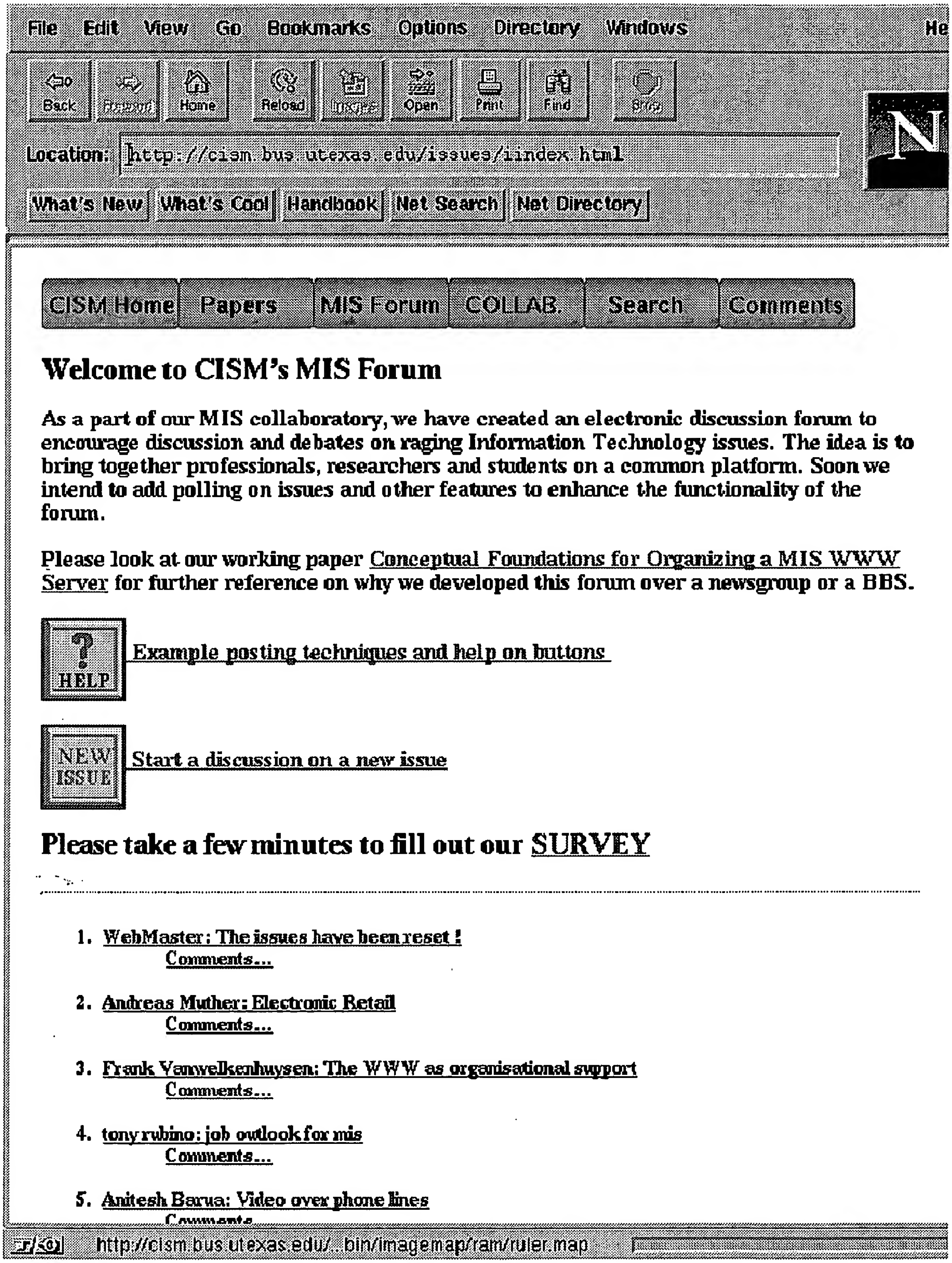
File Edit View Go Bookmarks Options Directory Windows
Back Forward Home Reload Images Open Print Find Stop
Location: http://cism.bus.utexas.edu/issues/iindex.html
What's New What's Cool Handbook Net Search Net Directory
CISM Home Papers MIS Forum COLLAB. Search Comments
Welcome to CISM's MIS Forum
As a part of our MIS collaboratory, we have created an electronic discussion forum to encourage discussion and debates on raging Information Technology issues. The idea is to bring together professionals, researchers and students on a common platform. Soon we intend to add polling on issues and other features to enhance the functionality of the forum.
Please look at our working paper Conceptual Foundations for Organizing a MIS WWW Server for further reference on why we developed this forum over a newsgroup or a BBS.
HELP
Example posting techniques and help on buttons
NEW ISSUE
Start a discussion on a new issue
Please take a few minutes to fill out our SURVEY
1. WebMaster: The issues have been reset !
Comments...
2. Andreas Muther: Electronic Retail
Comments...
3. Frank Vanwelkenhuysen: The WWW as organisational support
Comments...
4. tony rubino: job outlook for mis
Comments...
5. Anitesh Barua: Video over phone lines
http://cism.bus.utexas.edu/...bin/imagemap/ram/ruler.map

Figure 4: The MIS Forum

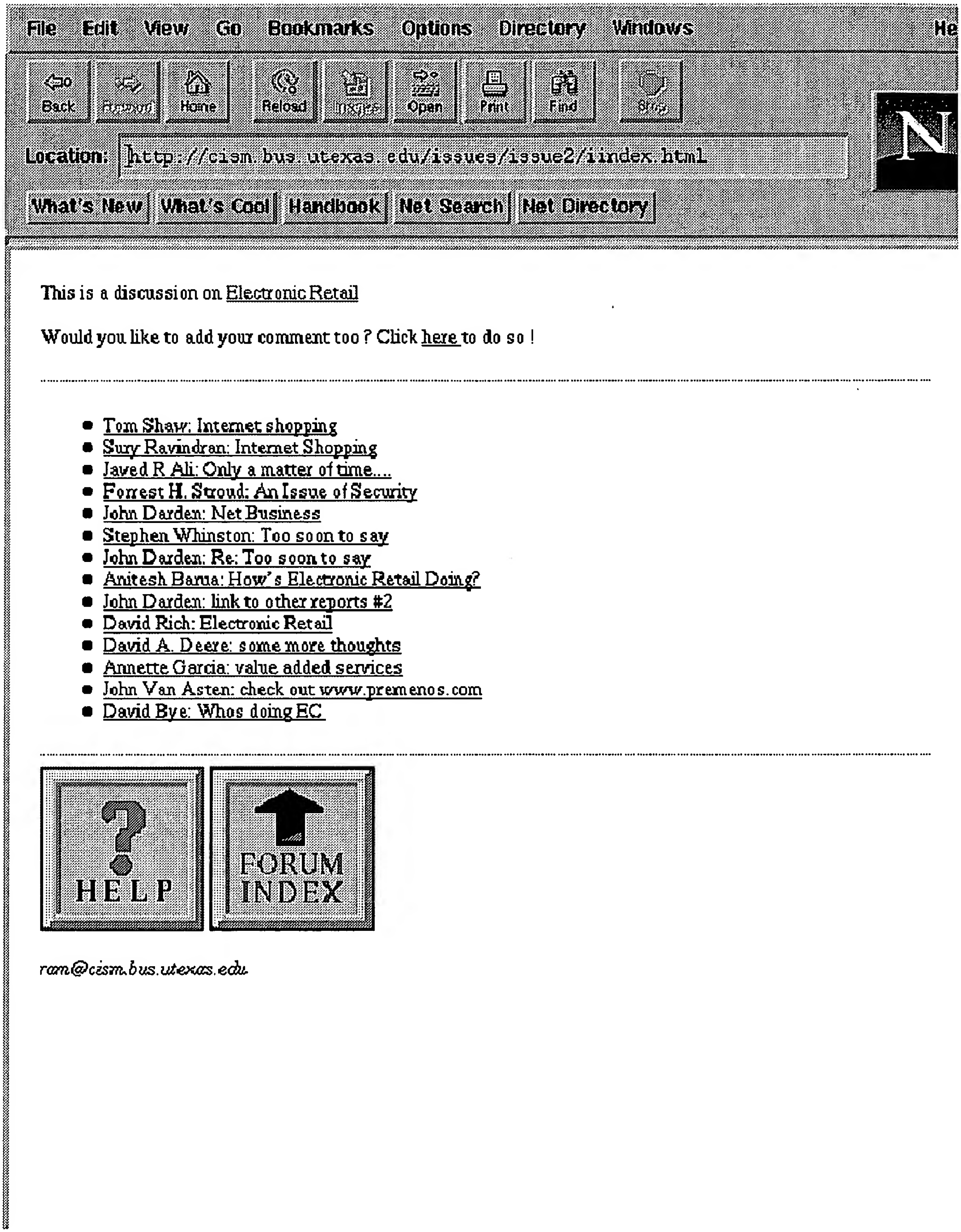

Figure 5: A Sample Discussion on the MIS Forum

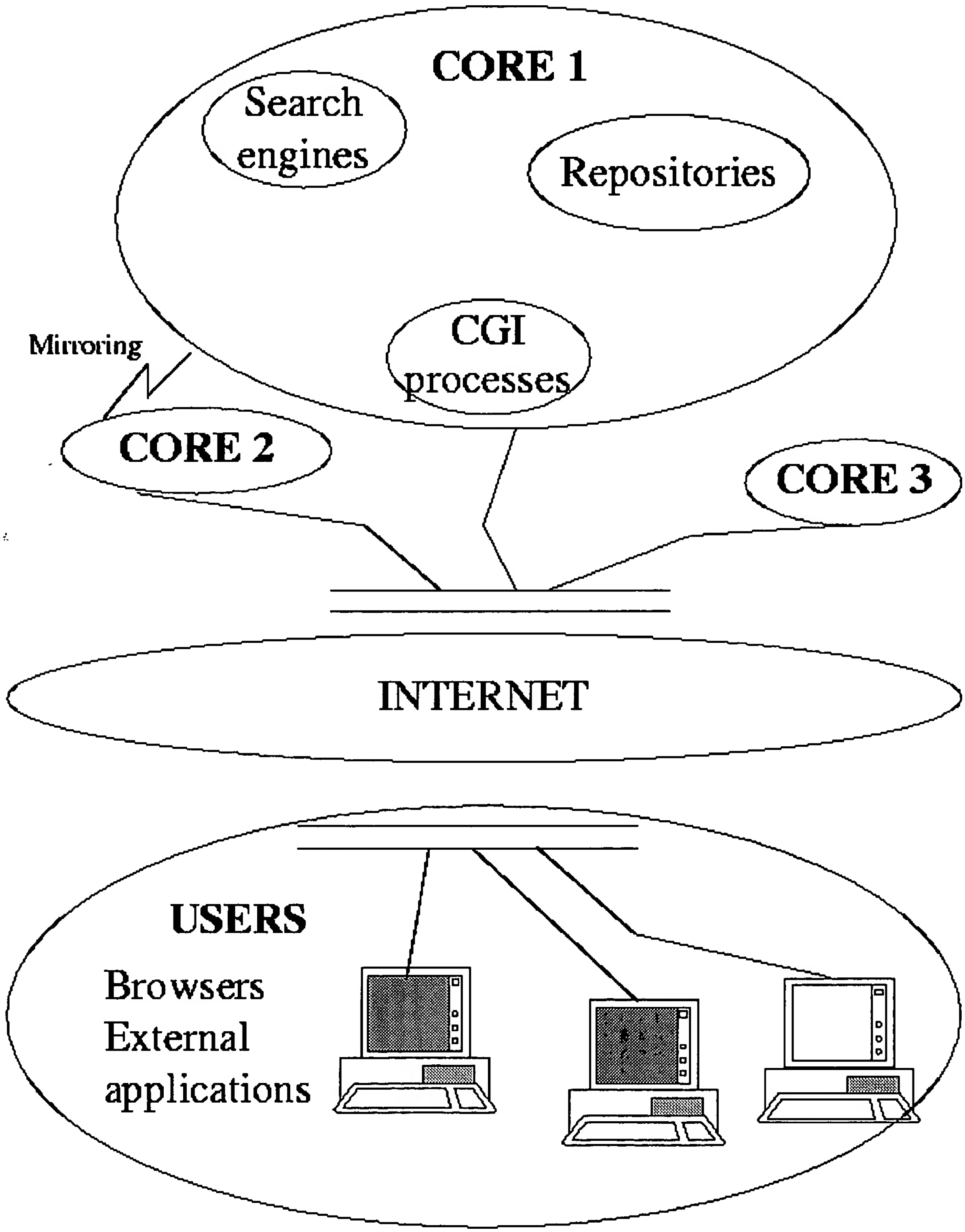

Figure 6: Proposed architecture for linking Collaboratories

About this document ...

in collaboration and document-based interactions through which academics and professionals in a given field exchange, disseminate and create new ideas and concepts. Accordingly, our view of collaboration is consistent with characteristics described by Hamalainen et al. [1].

...Notes

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...platform

Platform refers to the hardware, operating system and communication standards used by the GDSS or CSCW application.

...Internet

Even this capability is a very recent addition, made possible by expensive ``Internotes'' gateways to comply with the TCP/IP format used on the Internet.

...value

The implicit assumption is that the developer's benefit increases with the users' net benefits.

...viewpoints

Other fields may have different perspectives, which will govern the way information should be intellectually organized.

...Collaboratory

Refer to the URL *http://cism.bus.utexas.edu/*

...collaboration

The respondents were asked to rate the importance of various design features on the following five-point scale: ``not at all'', ``not very much'', ``somewhat'', ``quite a bit'' and ``very much''. For the survey questions, refer to the URL *http://cism.bus.utexas.edu/ram/survey/sur.html.*

Ram Chellappa
Thu Dec 12 19:23:07 CST 1996